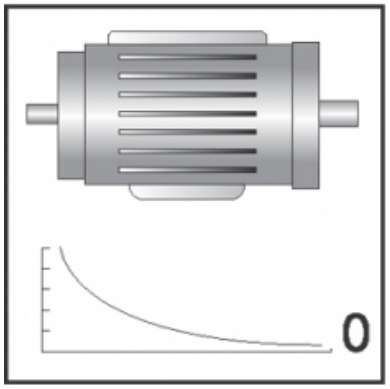
Safety Chain Solution – Zero Speed detection

PL e, SIL 3

Guarding machines with high inertia



Function:

- Safety-related stop function initiated by any stop or emergency stop command to halt the machine and to unlock the moveable guard that prevents the access to the hazardous area before the machine comes to a standstill.
- Guard opening is detected by using a solenoid locking interlock switch in combination with a limit switch in positive actuation mode, which are then checked by the safety module allowing detection of the opening or removal of the protective guard.
- Actuation of the emergency stop or stop contacts initiates the functional stopping of the machine by switching-off the motor power supply. As electric motors run down, a remanent voltage is produced in the windings of the motor due to residual magnetism.
- This voltage is measured so as to detect the stopped condition of the motor, providing the unlock signal for the electrically locked movable guard and for engaging brakes after the motor has come to a standstill.
- The continuity of the wiring between the motor windings and the inputs of the safety module is also monitored to prevent a cable breakage or fault being seen as a stopped motor
- The main contactors are monitored by the safety modules by means of the mirror contacts to detect e.g. contact welding.
- The safety modules also monitor the consistent actuation of the limit switch contacts to detect failure, before restart of the machine movement is permitted.

Typical applications:

- On metal, wood work or similar high inertia machines with a long run-down of the hazardous tool movements, and where an electronically interlock guard is used to protect the hazardous area.

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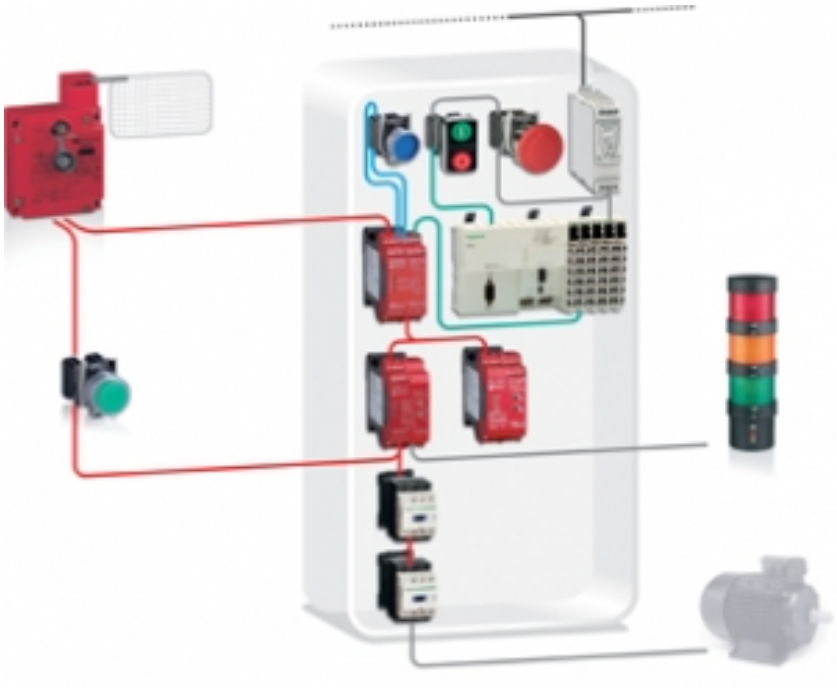
Design:

- The safety function employs well-tried safety principles and is robust in the event of a component failure by means of redundant contacts on the limit switch devices and two redundant contactors (K1 and K2).
- The contact synchronization of the limit switches and contactor failure are detected by the safety modules at the next demand on the safety function.
- The start (S4) and the restart interlock (S2) pushbutton must be located outside the hazardous area and at a point from which the potential danger is visible.
- The safety modules satisfy thel requirements for performance level PL e in accordance with EN ISO 13849-1 and SILCL 3 in accordance with EN/IEC 62061.
- The adjustable switching threshold in the safety module must be selected so that under the most unfavourable operating conditions, the machine movements will stop before the guard is unlocked.
- The contactors (K1 and K2) are considered as well-tried components.
- Protection against overcurrent must be provided in accordance with EN/IEC 60947-4-1.
- The contactors (K1 and K2) have mirror contacts in accordance with EN/IEC 60947-4-1, which are integrated into the feedback of the safety modules for contactor fault detection.



Related products

- Switches, pushbuttons, emergency stop - Harmony XB4
- Switch mode Power supply - Phaseo ABL8
- Logic controller - Modicon M258
- Guard interlock switch - Preventa XCSE
- Safety Module - Preventa XPS
- Contactor - TeSys D
- Modular beacon and tower lights - Harmony XVB

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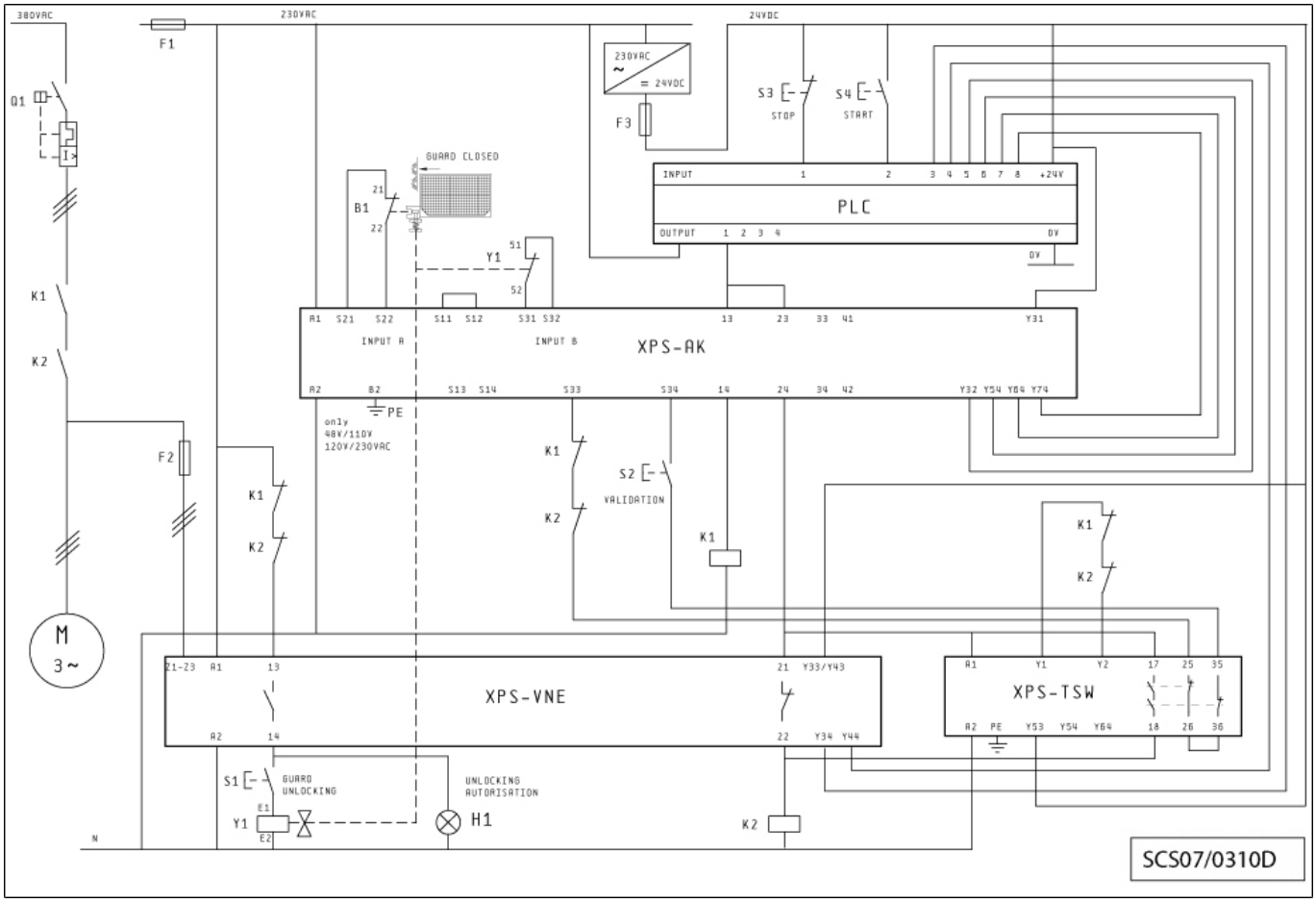

Chain structure:

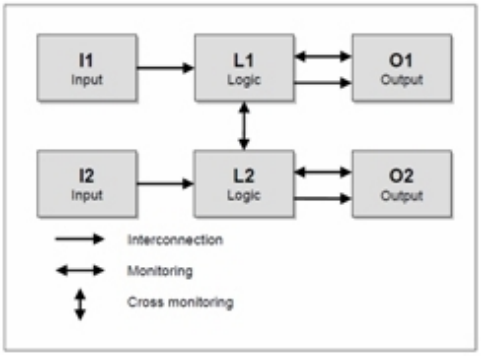

Figure 1

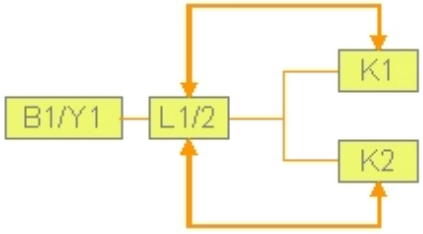

Figure 2

- The circuit diagram SCS07/0310D is a conceptual schematic diagram and is limited to present the safety function with only the relevant safety components.
- For the designated architecture of the category 4 system, two redundant channels are implemented.
- The circuit arrangement can be divided into two channels with the input (I), logic (L) and output (O) blocks on each channel.
- The unbroken lines for monitoring symbolize the higher DCavg assumed for this category (see figure 1).
- The functional channel is represented by the moveable guard switch device (B1/Y1) that would correspond to the input block (see figure 2).
- The safety module (XPSAK) correspond to the logic block (L1/L2), which maintains the internal redundancy of the safety circuits required for this category.
- The output block is represented by two redundant contactors (K1 and K2) that are monitored by the logic block (safety modules) to detect any failure.
- The complete wiring must be in accordance to EN 60204-1 and the necessary means to avoid short circuits has to be provided (EN ISO 13849-2 Table D.4).

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Cycle time (s)	300
Number of hours' operation per day (h)	12
Number of days' operation per year	220
Number of operations per year (n_{op})	31680

		Values	
		Channel 1	Channel 2
Input (guard switch) XCS	$B10_d$ (operations)	5 000 000	50 000 000
	T10d (years)	157.8	1578
	$MTTF_d$ (years)	1578.3	15782.8
	$MTTF_d$ resulting (years)	1578.3	2500
	PFH_d resulting (1/h)	1.09×10^{-9}	1.09×10^{-9}
	DC (%)	99	99
Logic (safety module) XPSAK	PFH_d (1/h)	7.39×10^{-9}	7.39×10^{-9}
Logic (safety module) XPSVNE	PFH_d (1/h)	9.26×10^{-9}	9.26×10^{-9}
Output (actuator) LC1	B10 (operations)	1 000 000	1 000 000
	% dangerous failure	73	73
	$B10_d$ (operations)	1 369 863	1 369 863
	$T10_d$ (years)	43	43
	$MTTF_d$ (years)	432.4	432.4
	$MTTF_d$ resulting (years)	432.4	432.4
	PFH_d resulting (1/h)	5.35×10^{-9}	5.35×10^{-9}
	DC (%)	99	99
Safety function	$MTTF_{dC}$	**58 (high)**	
	DC_{avg}	**99 (high)**	
	PFH_d resulting (1/h)	**2.31×10^{-8}**	
	PL attained	**e**	
	SIL attained	**3**	

Safety level calculation:

- A required performance level (PLr) must be specified for each intended safety function following a risk evaluation. The performance level (PL) attained by the control system must be validated by verifying if it is greater than or equal to the PLr.
- If the protective guard is assumed to be actuated every 5 minutes during 220 working days per year and 12 working hours, the number of operations (nop) would be 31 680.
- A B10d value of 5 000 000 cycles is stated for the solenoid locking switch. In accordance with the assumed above nop value, the MTTFd would be 1578.3 years for channel 1. These values are not limited in this case as this is a category 4 system and they are under the 2500 year limit used by the SISTEMA calculation tool.
- A B10d value of 50 000 000 cycles is stated for the limit switch. In accordance with the assumed nop value, the MTTFd would be 15782.8 years for channel 2. This value is limited to 2500 years for this case as this is a category 4 system.
- A PFHd value of 7.39×10^{-9} is stated for the first safety module (XPSAK) and a value of 9.26×10^{-9} is stated for the second safety module. As they are in series in the safety chain, both must be added for the total calculation. These values come directly from the safety device data and are certified by an accepted standards body.
- For the redundant contactors K1 and K2, the B10 value corresponds under nominal load to an electrical lifetime of 1 000 000 switching cycles. If 73% of failures are assumed to be dangerous, the B10d values is 1 369 863 operations. With the assumed value for nop, it results in a MTTFd of 432.4 years for each component. These values are not limited in this case as this is a category 4 system and they are under the 2500 year limit of SISTEMA calculation tool.
- Measures against common cause failures must attained at least 65 points (i.e. separation (15), diversity (20), over voltage protection etc. (15) and environmental conditions (25+10)).
- Since this is the highest performance level, both the MTTFd of each channel and the DCavg must be high.
- The combination of channel 1 and channel 2 results in a DCavg 99% (high) as we are monitoring the combination of guard switch contacts and using mirror contact monitoring for the contactors.
- The safety-related control system corresponds to category 4 with high MTTFd. The complete functional safety chain results in an average probability of dangerous failure (PFHd) of 2.31×10^{-8}.
- This corresponds to PL e and SIL 3.

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